

Pentavalent Vaccine in the Uniject™ Injection System

A Time and Motion Study

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Executive summary

Background

Fully liquid pentavalent vaccine combining five antigens for protection against potentially life-threatening childhood diseases—diphtheria, tetanus, pertussis, hepatitis B, and illnesses caused by *Haemophilus influenza* type B—is currently a component of national immunization schedules in at least 65 countries eligible to receive vaccines through the GAVI Alliance.¹ A new presentation of this vaccine, fully liquid pentavalent vaccine presented in the Uniject™ injection system,ⁱ is currently in development. This presentation is targeted for use in developing countries.

To understand the perceived benefits and challenges related to pentavalent vaccine in Uniject in comparison to alternative presentations of pentavalent vaccine, a time and motion study was planned in 2010 and carried out in 2011. This study was performed by experienced immunization personnel in Kenya.

Methodology

The time and motion study included 20 participants who were trained health professionals (nurses, nurse officers, community nurses, and district public health nurses). The health professionals were experienced in delivering pentavalent vaccine at several health facilities in and around Kakamega, Kenya. The participants were inexperienced with regard to the Uniject system. Testing stations were set up to test five vaccine formats: single-dose vials with liquid vaccine, single-dose vials with lyophilized vaccine, ten-dose vials with liquid vaccine, ten-dose vials with lyophilized vaccine, and single-dose liquid vaccine prefilled in the Uniject injection system. After receiving detailed instruction on the process and steps involved, the participants simulated injections with an orange for each of the five presentations. Participants were also asked a series of questions related to their background and experience with immunization.

After receiving training in the five presentations, each health worker was paired with an observer and asked to deliver 20 doses of a designated presentation into an orange. The vaccination session was simulated to mimic a real-life situation. After the session, the participants were encouraged to provide feedback.

Main findings

Data on time taken to complete each single vaccination were collected throughout the session and collated afterwards. The time to deliver each injection for individual presentations was averaged across the 20 participants.

ⁱ Uniject is a trademark of BD.

The most efficient delivery of sample vaccine in this simulated environment proved to be the Uniject injection system, followed by the ten-dose liquid vial, single-dose liquid vial, ten-dose lyophilized vial, and single-dose lyophilized vial presentations.

Conclusion

Time and motion study participants unanimously selected Uniject as their preferred presentation for pentavalent vaccine. They also all reported that this would be the preferred presentation of parents of children receiving pentavalent vaccinations. Overall, the time and motion results demonstrated that Uniject was the simplest presentation, associated with the fewest errors and the most efficient delivery in a simulated immunization environment.

1. Background

A fully liquid pentavalent vaccine presented in the Uniject™ injection systemⁱⁱ is currently in development. This presentation is targeted for use in developing countries. To obtain an understanding of the perceived benefits and challenges related to pentavalent vaccine in Uniject compared with alternative pentavalent vaccine presentations, a time and motion study was performed with experienced immunization personnel in Kenya.

1.1. Pentavalent vaccine

The pentavalent vaccine to be presented in Uniject is a fully liquid vaccine. It combines five antigens for protection against potentially life-threatening childhood diseases: diphtheria, tetanus, pertussis, hepatitis B, and illnesses caused by *Haemophilus influenzae* type B. The fully liquid vaccine is currently a component of national immunization schedules in at least 65 countries eligible to receive vaccines through the GAVI Alliance.¹

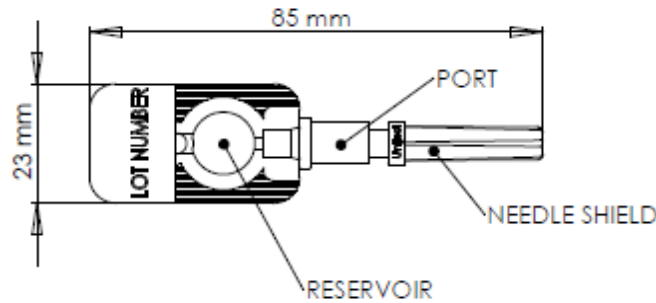
1.2. The Uniject™ injection system

The Uniject injection system is a commercially available product manufactured and marketed by BD, formerly Becton, Dickinson and Company.^{2–4} The Uniject injection system is a compact, prefilled, autodisable device for intramuscular and subcutaneous delivery of medicines (see Figure 1). The system delivers a precise amount of medication when the health care provider presses firmly on the prefilled reservoir. Once used, the device cannot be refilled or reused. PATH licensed Uniject's underlying intellectual property to BD in 1996, and BD launched Uniject to pharmaceutical and biological producers the same year. Uniject has been used to deliver drugs and vaccines in developing countries for over ten years;^{2,5–11} user acceptability, safety, and efficacy have been demonstrated in a range of public-health settings.^{10,11} More than 75 million doses of hepatitis B vaccine have been given to infants at birth in Indonesia using Uniject, and the United Nations Children's Fund (UNICEF) has used 9 million doses of tetanus toxoid in Uniject as part of the Maternal and Neonatal Tetanus Elimination program.

The Uniject design offers fast, simple, and accurate injections, while the compact size allows for easy transport, storage, and disposal. Tamper-evident packaging ensures safe, sterile injections.

ⁱⁱ Uniject is a trademark of BD.

Figure 1. BD Uniject injection system.ⁱⁱⁱ



1.3. Study objectives

Health worker time savings and product ease of use may significantly impact product demand as well as the experiences that the children receiving immunizations and their parents have. Thus, a time and motion study was conducted to characterize the user experience for pentavalent vaccines, including the benefits and challenges of a variety of product presentations. Information collected from this study will provide insight into health worker perspectives on pentavalent vaccine in Uniject relative to other presentations.

1.4. Study design and methodology

The time and motion study involved 20 health workers with experience in delivering pentavalent vaccines from several health facilities in and around Kakamega, Kenya. Upon arriving at the workshop, health workers were greeted and then seated at a station across from an individual with the task to observe, time, and record the simulated injections. Each station was equipped with 20 sample vaccine doses, the appropriate quantity and type of needle and syringes, and a sharps box (see Figure 2). Participants were asked to introduce themselves and were provided a verbal overview of the study, including information on available vaccine presentations for pentavalent vaccine and the objectives of the study. The observers then asked each health worker a series of questions related to their background and experience with immunization. This information was collected and collated at the end of the study.

All participants were trained health care professionals with varying job titles (16 nurses, 2 nurse officers, 1 community nurse, and 1 district public health nurse). No participant had used or seen a Uniject injection system prior to this workshop. The participants reported vaccinating an average of 33 children per day (range 10 to 100 per day) at their respective clinics and an average of 75 doses of pentavalent vaccine per week (range 10 to 200 per week). All but one of the participants performed outreach vaccination to the community. During outreach, the participants reported vaccinating an average of 16 children in one session. No participants reported requiring more than one day to perform an outreach session. Additional details obtained from participants are summarized in Appendix 1.

ⁱⁱⁱ A 0.5-ml Uniject injection system with a 23-gauge needle of 1-inch length prefilled with water was used in the study.

After the introductions, participants were oriented to the presentations at their respective stations. Five vaccine formats were included in the study: single-dose vials with liquid vaccine, single-dose vials with lyophilized vaccine, ten-dose vials with liquid vaccine, ten-dose vials with lyophilized vaccine, and single-dose liquid vaccine prefilled in the Uniject injection system. The participants were provided detailed instructions on the process and steps involved in the delivery of an injection. Following the training and demonstration, the participants were given the opportunity to practice giving one injection into an orange and were encouraged to ask questions if needed to clarify the study objectives and activities involved. This process was repeated for each of the five presentations.

Figure 2. Arrangement of health care worker time and motion station.



Photo: PATH

After the training and practice session, each health worker was paired with an observer and asked to deliver 20 doses of a designated presentation into an orange. The sequence of the presentations was randomized across participants to ensure that experience and fatigue did not influence performance (see Appendix 2). The time taken to deliver each injection, starting from the time to open the package, inject the orange, and dispose of materials in the safety box, was recorded by the observer. A period of one minute was inserted between each injection to simulate the time taken to interact with a vaccine recipient prior to giving an injection. A waiting period of approximately 45 minutes was inserted between each set of 20 injections to ensure that fatigue was not a factor in the comparison of presentations. Throughout the simulated vaccination session, observers accounted for any problems or errors that occurred in the process steps. During and after each set of injections, health workers were encouraged to provide feedback on their experience of administering injections.

1.5. Sample vaccine presentations

Sample vaccine presentations for single-dose liquid and lyophilized vials, standard autodisable syringes, and reconstitution syringes were procured from a Kenyan pharmaceutical distributor prior to the

workshop to control the cost of supplies for the study and to reduce issues posed by customs and import. Single-dose liquid hepatitis B vaccine and single-dose lyophilized combination measles, mumps, and rubella (GlaxoSmithKline's Priorix®^{iv}) vaccine were purchased locally (see Figures 3 and 4). The Priorix presentation included diluent in a glass prefilled syringe with a separate needle for dispensing into the vial of lyophilized vaccine. Participants were instructed to open the plastic container, attach the threaded needle to the syringe prefilled with diluent, extract diluent into the vial, and then use an autodisable syringe to draw reconstituted vaccine and simulate an injection into the orange.^v

Uniject samples prefilled with water were sent by BD, and prototype ten-dose packaging trays were sent by Crucell to the PATH office in Nairobi, Kenya for the study. Given that these prototypes were custom manufactured for the purpose of the study, 20 trays were received and reused four times throughout the study in order for each ten-dose injection simulation to begin with a full tray of Uniject samples.

Ten-dose vaccine presentations are not available in Kenya. Therefore, ten-dose vials containing water to simulate diluent and ten-dose vials containing an artificial sweetener to simulate lyophilized vaccine were filled in the PATH office in Seattle and shipped to the PATH office in Nairobi prior to the workshop. Several dissolvable substances were tested prior to filling the ten-dose "lyophilized vaccine" simulated vials. Aspartame (Equal and NutraSweet brands), sucralose (Splenda brand), sugar, and salt were sampled to determine which substance diluted the fastest when combined with water at ambient temperature. The speed of dissolution in water was the fastest for Equal, which was thus selected as the dissolvable substance. The speed of dissolution of the substitute material was not compared to that of a real lyophilized vaccine, but this was assumed to dissolve within a few seconds, similar to that of Equal.

Figures 3–7 illustrate the sample vaccine or simulated vaccine presentations included in the time and motion study.

Figure 3. Single-dose liquid vial with autodisable syringe.



Photo: PATH



Photo: PATH

Participants were instructed to use only one of the prepackaged needles to expel the prefilled diluents into the vial of lyophilized vaccine for reconstitution. An autodisable syringe was then used to draw the reconstituted dose and inject into the orange.

^{iv} Priorix is a registered trademark of GlaxoSmithKline.

^v Ideally, the single-dose diluent would have been packaged in a single-dose vial similar to that of the World Health Organization prequalified pentavalent vaccines available through UNICEF (i.e., marketed formulations were not used). Unfortunately, this was not noticed until the day of the study, and, therefore, we proceeded with the available presentation.

Figure 4. Single-dose lyophilized vial with prefilled diluent and autodisable syringe.



Photo: PATH



Photo: PATH

Figure 5. Single-dose compact prefilled Uniject injection system in a ten-dose prototype resealable pouch.



Photo: PATH

Figure 6. Ten-dose liquid vial with autodisable syringe.

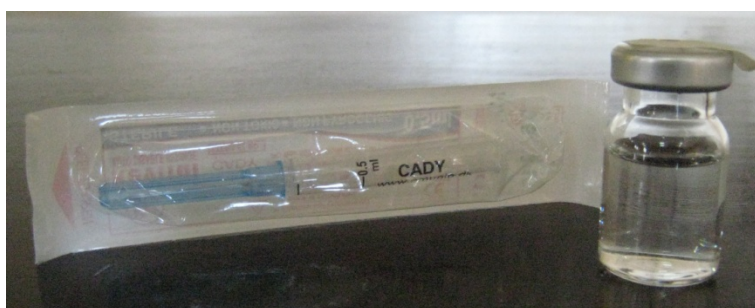


Photo: PATH

Figure 7. Ten-dose lyophilized vial and a ten-dose diluent vial with reconstitution syringe and autodisable syringe.

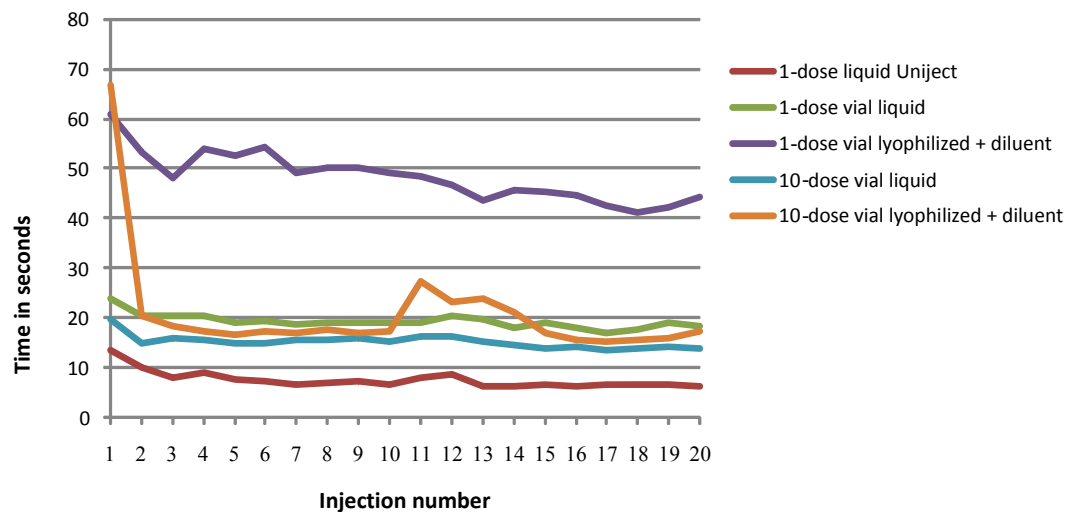


Photo: PATH

2. Results

Timing data and comments collected throughout the study were analyzed following the workshop. The injections were numbered 1 to 20. The time taken to give the 20 individual injections was averaged for each participant and for each presentation (see Figure 8).

Figure 8. Average time taken for the 20 health care workers to prepare and inject the individual doses of five different vaccine presentations.



The delivery of sample vaccine in this simulated environment was fastest using the Uniject injection system, followed by the ten-dose liquid vial, the single-dose liquid vial, the ten-dose lyophilized vial, and the single-dose lyophilized vial (see Table 1), on a per dose basis.

Table 1. Average time across 20 health workers to deliver one dose by presentation type.

Presentation type	Average time to deliver one dose (seconds)
One-dose liquid Uniject	7.6
Ten-dose vial liquid	15.2
One-dose vial liquid	19.3
Ten-dose vial lyophilized + diluent	20.9
One-dose vial lyophilized + diluent	48.3

Figures 9a–13a show the time taken to deliver each dose of vaccine per presentation per participant. Figures 9b–13b show the average time taken to deliver each dose of vaccine per presentation, including the maximum and minimum times. The advantages, disadvantages, and problem areas across presentation types are also presented as a result of the qualitative data collected by the observers throughout the study and are detailed in Appendix 3.

Figure 9a. Single-dose liquid vial: delivery time per dose per participant.

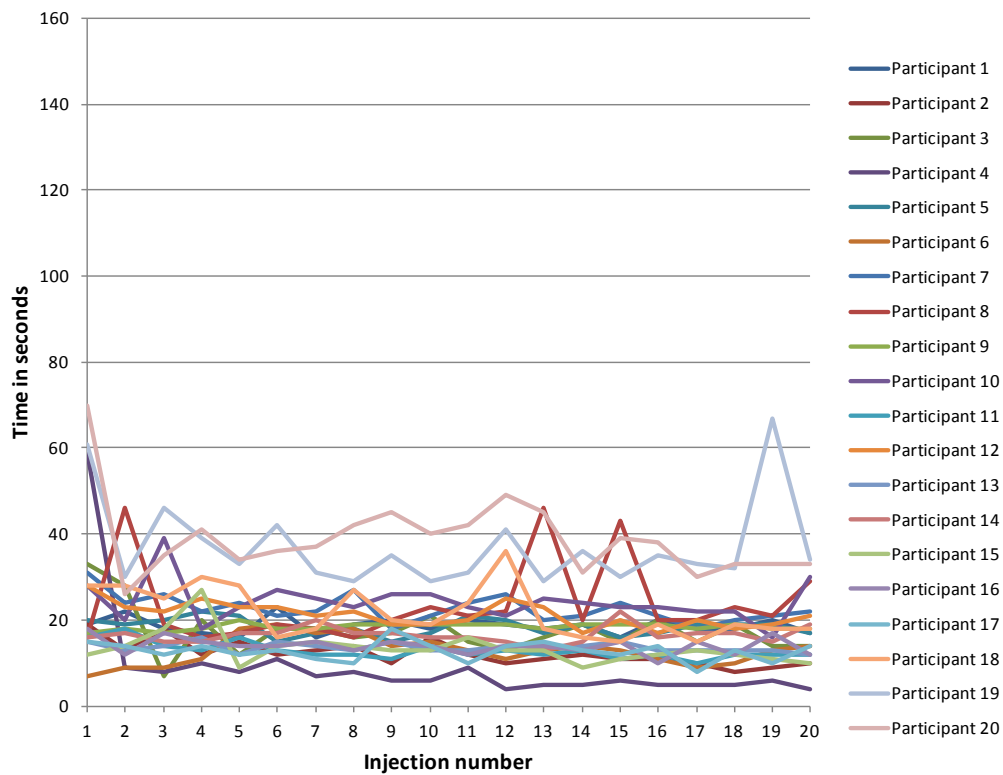
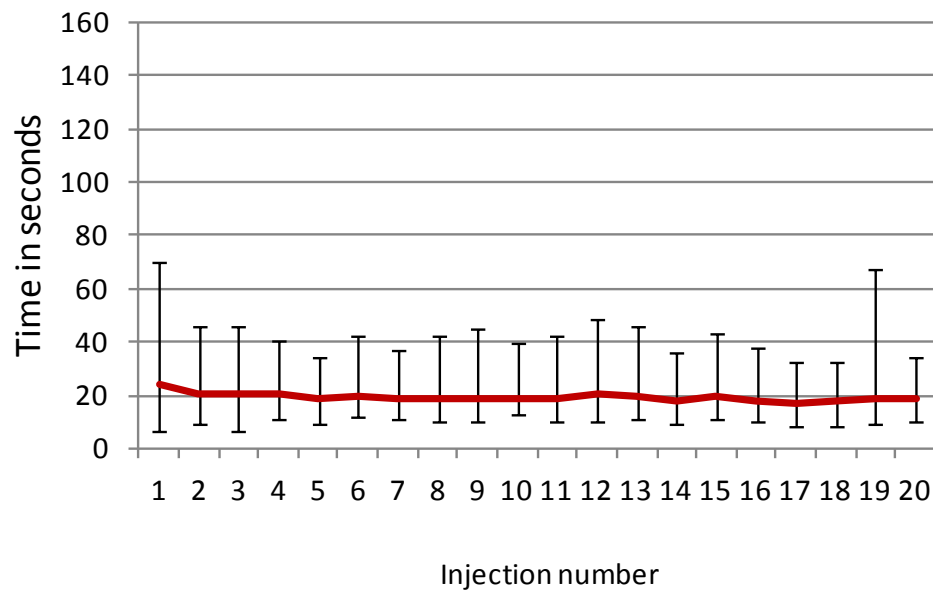


Figure 9b. Single-dose liquid vial: average delivery time per dose.



For the single-dose liquid vial, half of the participants claimed that it was difficult to remove the plastic cap from the top of the single-dose vial. Three participants reported that the autodisable needles were fragile or faulty and broke or bent while performing injections.

Figure 10a. Single-dose lyophilized + diluent vial: delivery time per dose per participant.

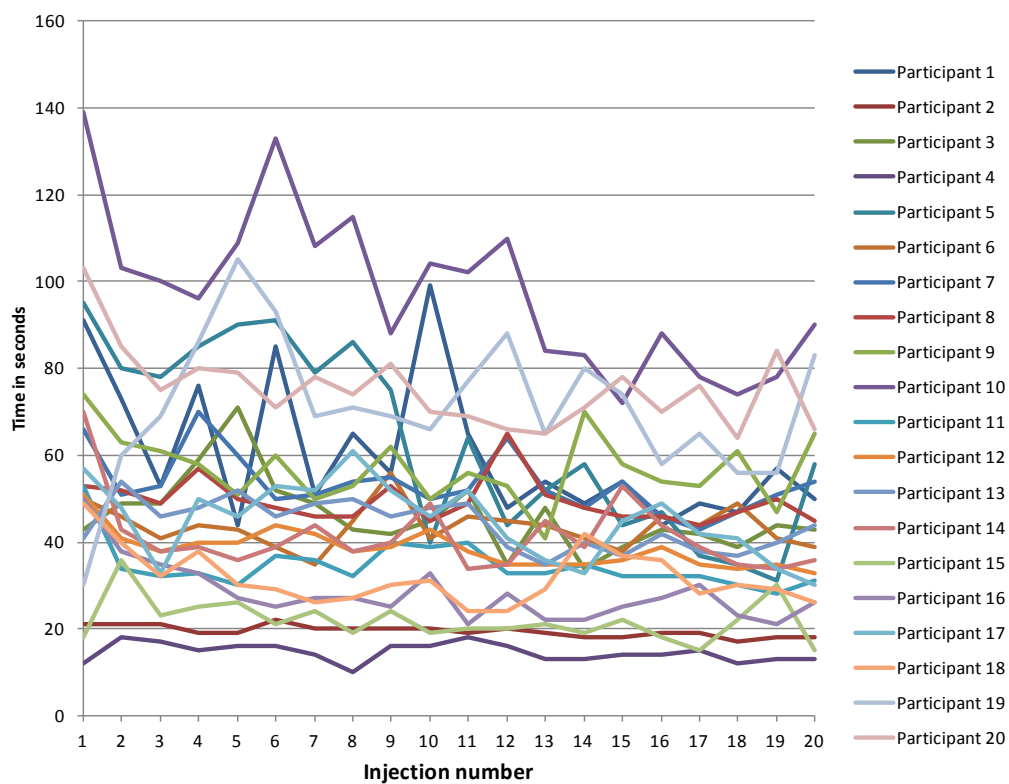
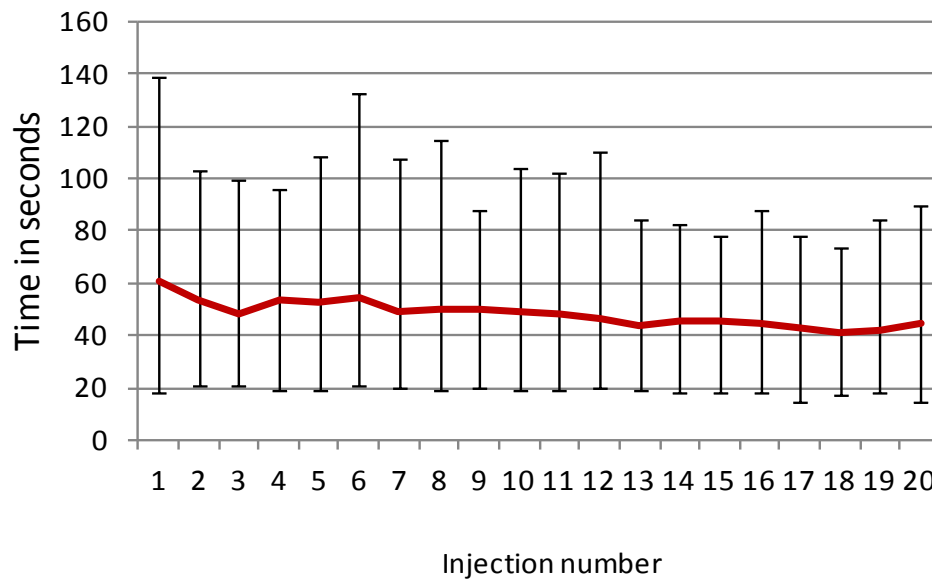


Figure 10b. Single-dose lyophilized + diluent vial: average delivery time per dose.



Participants reported that the single-dose lyophilized presentation required too many steps and was tedious, tiresome, and time consuming. Three participants commented on the faulty and fragile nature of the syringes.

Figure 11a. Single-dose liquid Uniject: delivery time per dose per participant.

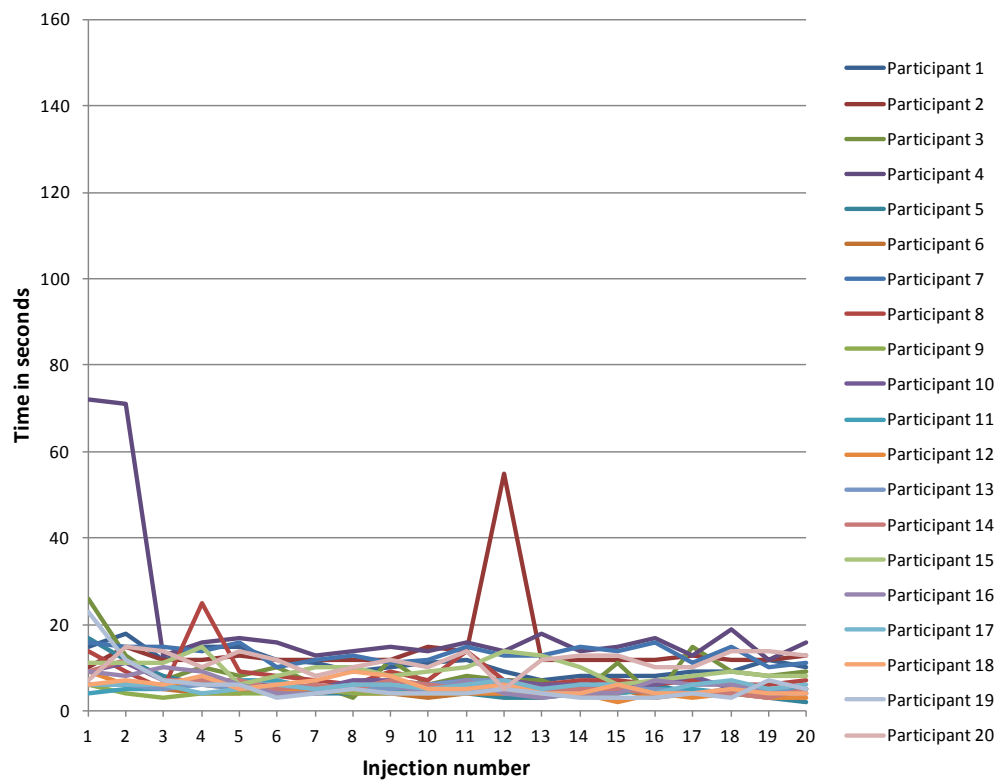
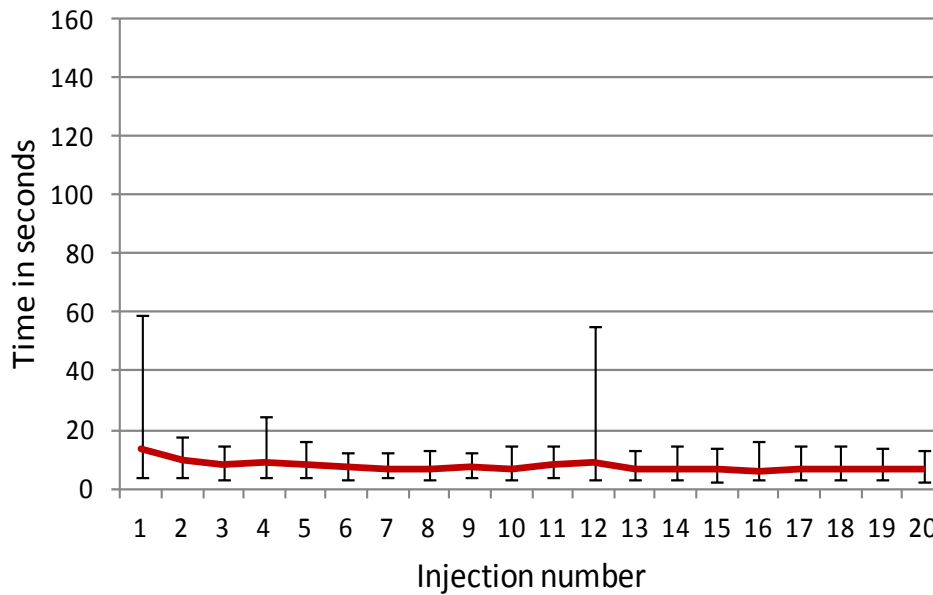


Figure 11b. Single-dose liquid Uniject: average delivery time per dose.



Participants generally provided positive comments on the experience with Uniject. For example, one participant reported that Uniject is convenient, simple, and easy to use; provided an accurate dose; and saved time. Two participants reported difficulty in removing the Uniject injection system from the prototype packaging tray. Several participants commented on the small size and opening of the tray. On dose 12, one participant encountered a faulty Uniject injection system and needed to redo the injection. There was one reported comment about needlestick injury when using Uniject; however, this issue did not reoccur after the initial incident.

Figure 12a. Ten-dose liquid vial: delivery time per dose per participant.

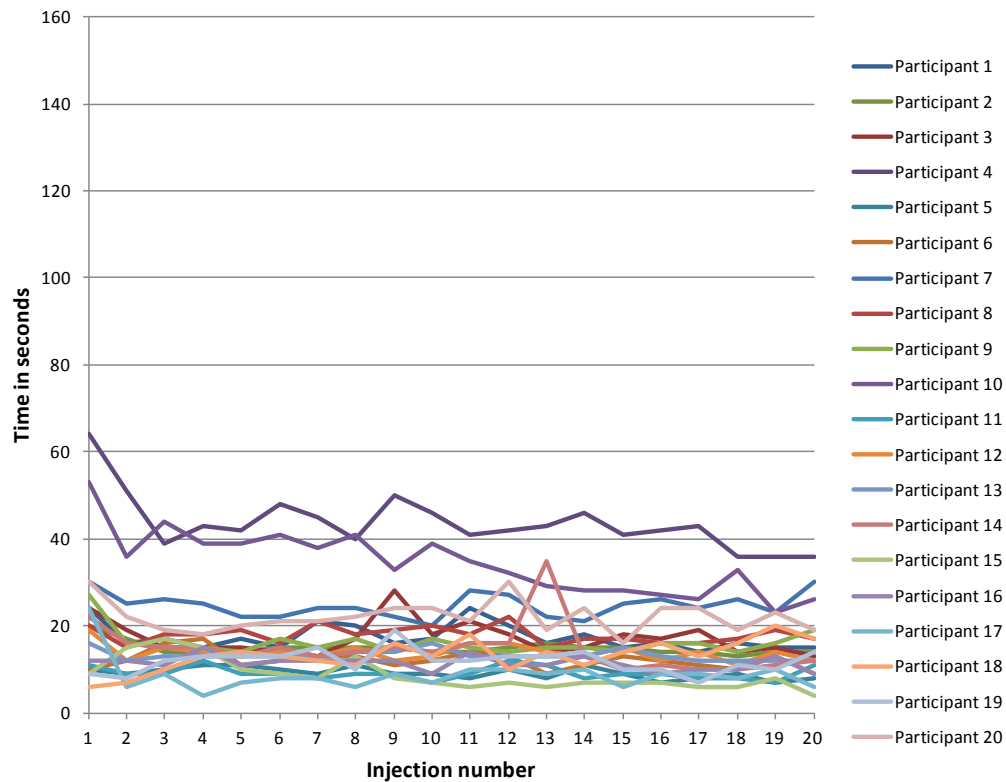
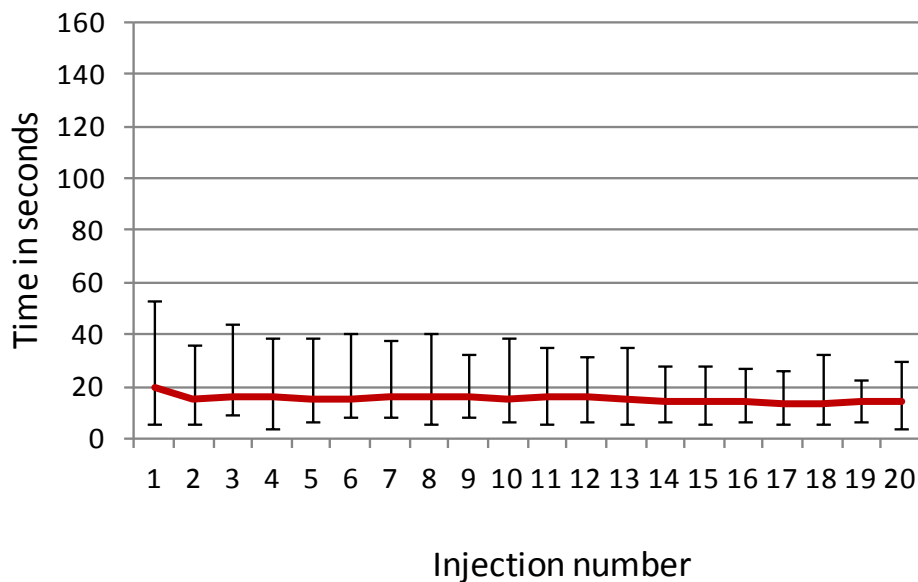


Figure 12b. Ten-dose liquid vial: average delivery time per dose.



Six participants said that preparation and administration with the ten-dose liquid presentation was easy. Four individuals commented that it was tedious or time consuming. Seven of the 20 participants commented that the septum of the vial was difficult to penetrate and/or the needles were too fragile. Two

participants reported that needles broke or bent during withdrawal or injection of the “vaccine.” A comment was made that dose accuracy was difficult.

Figure 13a. Ten-dose lyophilized + diluent vial: delivery time per dose per participant.

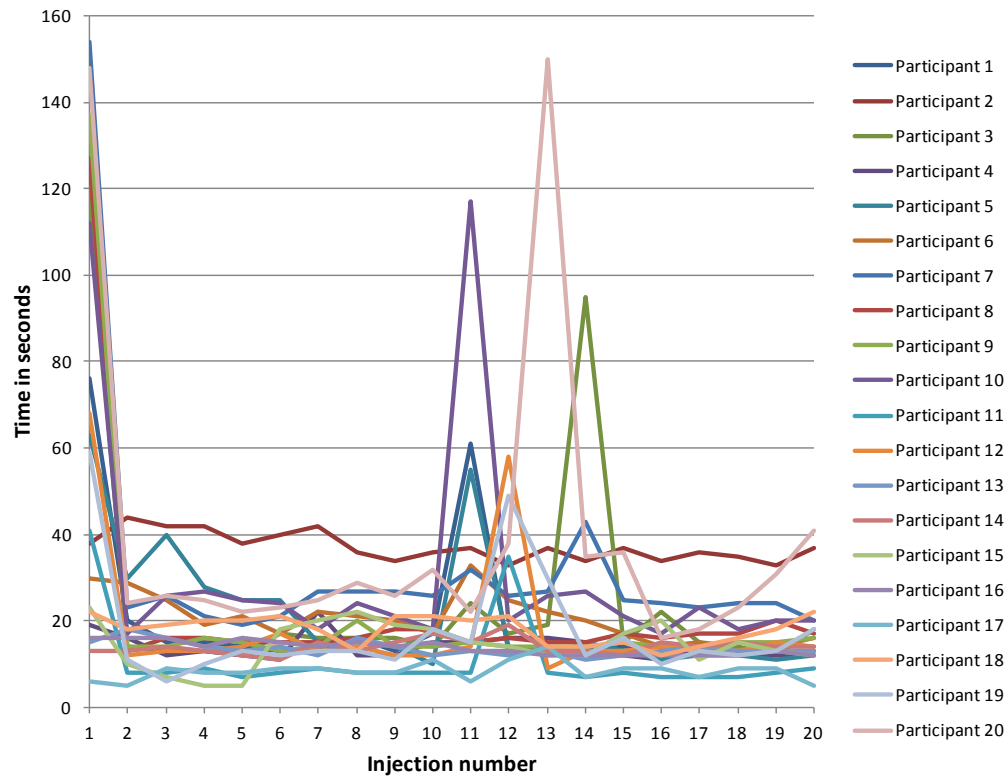
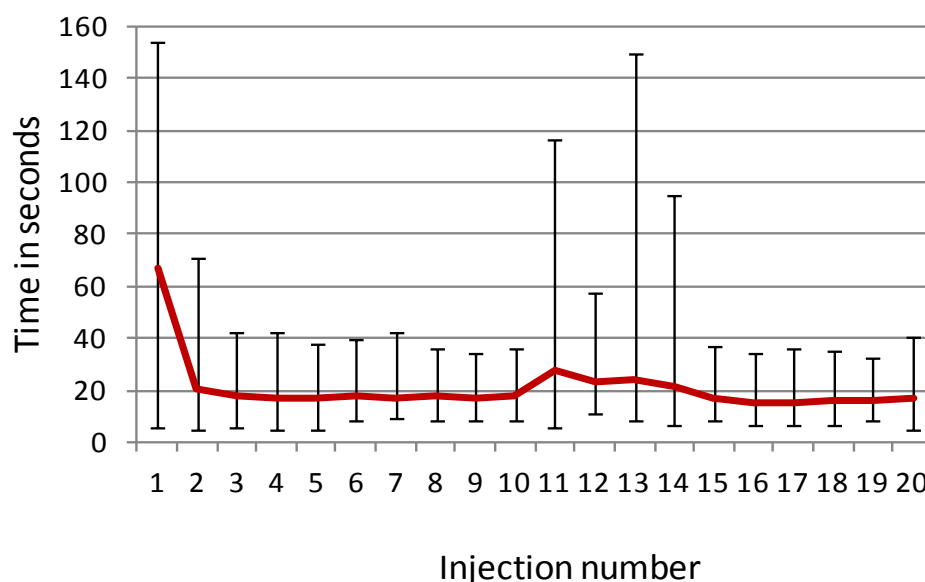


Figure 13b. Ten-dose lyophilized + diluent vial: average delivery time per dose.



Four participants commented that the ten-dose lyophilized presentation was easy to use and convenient. However, six participants commented that this presentation was time consuming, and several referenced the long time it took to completely dissolve the sample “vaccine.” Three participants commented that the septum was difficult to penetrate, and four participants reported fragile or broken needles. Remarks on the difficulty of dosing accuracy and the high consumption of syringes were also recorded.

3. Discussion and recommendations

Fully liquid pentavalent vaccines for childhood immunization are available as both single-dose vials and as multidose vials (MDVs). However, there are multiple challenges and concerns with MDVs that could impact an immunization program.

The type and size of the primary vaccine container affects vaccine distribution and administration, such as the storage and transport required throughout the immunization supply chain, the amount of vaccine wastage, the operations of immunization locations, and the safety of immunizations. One of the key aspects is that vial size affects injection safety in terms of the potential for contamination and re-use. MDVs have been implicated in the transmission of infectious diseases, particularly pyogenic cocci and bloodborne viruses (e.g., HIV and hepatitis B and C).^{12–17}

Single-dose fully liquid vial presentations reduce potential handling errors such as incorrect dosing, cross contamination, and subsequent adverse events associated with reconstitution of lyophilized vaccines. They also reduce administration time in comparison to lyophilized MDVs and single-dose vials (particularly important in high-throughput vaccination centers), reduce vaccine wastage, and are preservative free.

Uniject compact prefilled autodisable vaccine injection systems offer additional advantages to immunization programs in terms of safety: the injection system cannot be re-used, hence reducing cross-contamination and risk of bloodborne disease transmission. Vaccines prefilled in Uniject are ready to use (fewer preparatory steps before administration in comparison to single-dose vials and MDVs), reduce vaccine wastage as with single-dose liquid vial presentations, reduce the volume of medical waste (no syringes needed, eliminates glass vials from the waste stream), offer simplified logistics (no need for separate syringes, less need for dry storage capacity), and simplify delivery, enabling outreach strategies to increase immunization coverage.

This study was limited by factors associated with constraints in procuring supplies that are not typically available or readily accessible in Kenya. This resulted in suboptimal equipment for use in this study. An example is the single-dose lyophilized presentation. These were prepackaged with diluent prefilled in a glass syringe, which increased the complexity beyond a typical single-dose lyophilized vaccine presentation as distributed by UNICEF. As this presentation was not a marketed vaccine formulation, it did not serve as an ideal product for evaluation in this study because it may have exaggerated delivery times. The prefilled nature of the diluent may have been perceived as an advantage, but the plastic encasement and separate needle may have added complexity and time for delivery.

Caps on the single-dose liquid vials were perceived to be difficult to remove. Autodisable and reconstitution syringes procured for the study appeared to be less adequate than those the health workers were accustomed to using. In addition, the ten-dose vials filled in PATH's product development shop in Seattle were sealed with septa that were reported to be tough to penetrate with needles. This vial characteristic compounded with the weak and faulty needles may have triggered the perception by participants that Uniject was a sharper, thinner, and/or stronger needle since septum penetration was not required to draw the dose prior to injection in the orange.

Two participants reported difficulty in removing the Uniject injection system from the packaging tray. This was likely due to the fact that the prototype trays used in the study were too small to comfortably accommodate ten Unijects. One participant also reported a faulty Uniject, which may have been associated with failure to fully activate the Uniject prior to injection, or perhaps with damage to the Uniject when the packaging trays were refilled. There was no reported comments about needlestick injury when using Uniject; however, this issue did not occur again after the initial incident. These experiences suggest that training, which is standard protocol, and product attributes that may help to mitigate the lack of device activation or needlestick injury, such as holding the device in the wrong manner, could be explored to enhance user acceptability.

For the ten-dose presentation, the lyophilized simulation compound (Equal) dissolved rapidly when preparing the sample vials in the PATH machine shop; however, it did not perform as well during the study. Several comments regarding the slow dissolution time of the sweetener correlated with extended times being recorded for the reconstitution step in the first and eleventh injections. The slow reconstitution may have been due to the compromised dryness of the sweetener. The vials were shipped from Seattle to Nairobi in the same box with the water-filled vials and were wrapped in groups of ten in bubble wrap.

The sequence of presentations was randomized across the 20 subjects. Analysis of results did not indicate a trend associated with a particular order of presentation type influencing the speed of subsequent

presentations. The Uniject injection system was perceived to be the easiest, fastest, and most preferred presentation by health workers in the study.

4. Conclusions

Time and motion study participants unanimously selected Uniject as their preferred presentation for pentavalent vaccine. They also all reported that this would be the preferred presentation of parents of children receiving pentavalent vaccinations. Overall, the time and motion results demonstrated that Uniject was the simplest presentation, associated with the fewest errors and most efficient delivery in a simulated immunization environment.

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Appendix 1. Immunization experience of time and motion study participants

Job title	Location of employment	Average number of children immunized in one day for routine immunization	Average number of pentavalent vaccine doses delivered in one week in clinic	Perform outreach immunization to the community?	Average number of children immunized in one day during outreach
Nurse	Provincial General Hospital, Kakamega	60 to 100	200	Yes	40
Nurse	Shiseso Health Center	30	30	Yes	5
Nurse	Shingalu Health Center, Kakamega East	25 to 30	25 to 30	Visit 4 sites, monthly	25 to 30
Nurse	Sabatia Health Center	20	40 (Mondays are busiest)	Yes	20
Nurse	Malana District Hospital, Kakamega North	50	150	Yes	15
Nurse	Banja Health Center, Hamisi District	30	40	Yes	20
Nursing officer	Health center, Matungu District	25	50	Yes	15
Nursing officer	Health center, Ninega District	35	75	Visit 3 sites, monthly	5
Community nurse	Shisava dispensary	20	40	Yes	8 to 12
Nurse	Kakamega North Health Center	20	40	Yes	10
Nurse	Dispensary	20	50	Yes	10

Job title	Location of employment	Average number of children immunized in one day for routine immunization	Average number of pentavalent vaccine doses delivered in one week in clinic	Perform outreach immunization to the community?	Average number of children immunized in one day during outreach
Nurse	Dispensary	10 every day, except 30 on Thursdays, market days	50	Visit 2 sites, monthly	0
Nurse	Hospital	20	50	Yes	10
Nurse	Health center	15	40	Visit 4 villages, monthly	10
Nurse	Dispensary, Muhubu, Mamisi	15	35	Visit 4 sublocations, monthly, every Thursday	20
Nurse	Kegondi (West Maragoli) Health Center	10	20	Yes	12
Nurse	Bushin Health Center, Kakamega	80	200	Visit 9 villages, spaced out for monthly visits	30
Nurse	Butere District, Mabohe Health Center, Lucharge	15	10	Visit 3 catchment sites, monthly, every Thursday	20 to 40
District public health nurse	Kakamega Central Ministry of Health office	100	300	Visit 4 sites, monthly, every Wednesday	Unknown
Nurse	Vihiga district hospital	20	50	Yes	15

Appendix 2. Sequence of doses delivered by health workers

Participant	Presentation 1	Presentation 2	Presentation 3	Presentation 4	Presentation 5
1	1-dose liquid Uniject™ injection system	1-dose vial liquid	1-dose vial lyo + diluent	10-dose vial liquid	10-dose vial lyo + diluents
2	1-dose vial liquid	1-dose vial lyo + diluent	10-dose vial liquid	10-dose vial lyo + diluent	1-dose liquid Uniject
3	1-dose vial lyo + diluent	10-dose vial liquid	10-dose vial lyo + diluent	1-dose liquid Uniject	1-dose vial liquid
4	10-dose vial liquid	10-dose vial lyo + diluent	1-dose liquid Uniject	1-dose vial liquid	1-dose vial lyo + diluents
5	10-dose vial lyo + diluent	1-dose liquid Uniject	1-dose vial liquid	1-dose vial lyo + diluent	10-dose vial liquid
6	10-dose vial lyo + diluent	10-dose vial liquid	1-dose vial lyo + diluent	1-dose vial liquid	1-dose liquid Uniject
7	1-dose liquid Uniject	10-dose vial lyo + diluent	10-dose vial liquid	1-dose vial lyo + diluent	1-dose vial liquid
8	1-dose vial liquid	1-dose liquid Uniject	10-dose vial lyo + diluent	10-dose vial liquid	1-dose vial lyo + diluents
9	1-dose vial lyo + diluent	1-dose vial liquid	1-dose liquid Uniject	10-dose vial lyo + diluent	10-dose vial liquid
10	10-dose vial liquid	1-dose vial lyo + diluent	1-dose vial liquid	1-dose liquid Uniject	10-dose vial lyo + diluents
11	1-dose liquid Uniject	1-dose vial liquid	1-dose vial lyo + diluent	10-dose vial liquid	10-dose vial lyo + diluents
12	1-dose vial liquid	1-dose vial lyo + diluent	10-dose vial liquid	10-dose vial lyo + diluent	1-dose liquid Uniject
13	1-dose vial lyo + diluent	10-dose vial liquid	10-dose vial lyo + diluent	1-dose liquid Uniject	1-dose vial liquid
14	10-dose vial liquid	10-dose vial lyo + diluent	1-dose liquid Uniject	1-dose vial liquid	1-dose vial lyo + diluents
15	10-dose vial lyo + diluent	1-dose liquid Uniject	1-dose vial liquid	1-dose vial lyo + diluent	10-dose vial liquid
16	10-dose vial lyo + diluent	10-dose vial liquid	1-dose vial lyo + diluent	1-dose vial liquid	1-dose liquid Uniject
17	1-dose liquid Uniject	10-dose vial lyo + diluent	10-dose vial liquid	1-dose vial lyo + diluent	1-dose vial liquid

Participant	Presentation 1	Presentation 2	Presentation 3	Presentation 4	Presentation 5
18	1-dose vial liquid	1-dose liquid Uniject	10-dose vial lyo + diluent	10-dose vial liquid	1-dose vial lyo + diluents
19	1-dose vial lyo + diluent	1-dose vial liquid	1-dose liquid Uniject	10-dose vial lyo + diluent	10-dose vial liquid
20	10-dose vial liquid	1-dose vial lyo + diluent	1-dose vial liquid	1-dose liquid Uniject	10-dose vial lyo + diluents

lyo = lyophilized

Note: Uniject is a trademark of BD.

Appendix 3. Time and motion study qualitative feedback

Participant	1-dose liquid Uniject	1-dose vial liquid	1-dose vial lyo + diluent	10-dose vial liquid	10-dose vial lyo + diluents
1	Removing the Uniject™ injection system from package was difficult	Difficult to break off the yellow cap; not an economical presentation	Difficult to open package; time consuming, long procedure	Rubber septum is too hard to reposition needle for injection	Rubber septum is too hard
2	One broken Uniject; have to press hard to inject dose	Easy to use; prefer Uniject	Do not like syringes	Okay, easy	Okay, easy
3	Very keen; patient will like this presentation	Not stressful; requires training, skilled worker	Requires training, skilled worker; syringe consumption high	No comment	Syringe consumption high
4	Time saving	Syringe was faulty	Takes long time to dilute lyo powder; bulky presentation	Syringes were faulty	Syringes were faulty
5	Easy, time saving	Removing cap is hard	Tiresome, time consuming; easy to inject	Dose accuracy difficult	Tiresome, time consuming
6	Accurate, time saving	Hard to open	Tedious, time consuming	Tedious	Time consuming
7	Convenient	Hard to break cap off	Fragile syringe, cannot avoid needle prick	Tedious	Fragile syringe, dilution takes time
8	Time saving	Syringe fragile	Easy to prick oneself	Time consuming	Dilution is tedious, takes time
9	No comment	Hard to remove cap; not accurate	Hard to open; time consuming to reconstitute	Septum is hard, makes needle blunt; not accurate	Time consuming diluting; not accurate
10	Easy to use, no piercing septum, fast	Hard to remove cap	Hard to remove cap; not accurate dose; pricked finger	Easy, convenient, not accurate	Easy, not fast

Participant	1-dose liquid Uniject	1-dose vial liquid	1-dose vial lyo + diluent	10-dose vial liquid	10-dose vial lyo + diluents
11	Saves time	More than one dose, wastes vaccine; saves time	Stressful to open, wastes time	Easy to use	Mixing diluent took long time
12	Best	Not tedious	Difficult to open; wastes time	Bent needle inside orange; easy to use	Septum too hard
13	Convenient; no wastage	Good	Long process	Not tedious	Easy to do
14	Injured finger, easy, fast	Difficult to remove cap	Tiresome	Easy	Needle broke
15	Simple, fast, easy	Cap is difficult to remove; needle is short	Too many gadgets; needle too short; wastes time	Delicate needles; easy to use	Technical
16	Convenient; fast	Cap too tight; wastes time	Too many gadgets; time consuming; hectic	Needle breaks when withdrawing	Convenient
17	Squeezing liquid was tedious	Removing cap is hard	Takes too long to prepare	Septum is hard; difficult to insert needle	Septum is hard, making withdrawing liquid difficult
18	Removing Uniject from package was difficult	Easy to use	Takes time to prepare	No comment	Dissolving takes time
19	No comment	Faulty syringes	Faulty syringes	No comment	Faulty syringes
20	No comment	No comment	No comment	No comment	No comment

lyo = lyophilized

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